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EDITED BY
Tapan Kumar Nath,
University of Nottingham Malaysia Campus, Malaysia

REVIEWED BY
Abdus Subhan Mollick,
Khulna University, Bangladesh
Mohammed Jashimuddin,
University of Chittagong, Bangladesh

*CORRESPONDENCE
Eleonora De Falcis
e.defalcis@cgiar.org

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Strengthening the economic sustainability of community seed banks. A sustainable approach to enhance agrobiodiversity in the production systems in low-income countries

Eleonora De Falcis[1]*, Devendra Gauchan[1,2], Rose Nankya[3], Sergio Martinez Cotto[4], Devra I. Jarvis[1,2], Laura Lewis[2] and Paola De Santis[1,2,5]

[1]Genetic Diversity, Production and Resilience, Alliance Bioversity International and CIAT, Rome, Italy, [2]Platform for Agrobiodiversity Research (PAR) c/o The Raffaella Foundation, Twisp, WA, United States, [3]Alliance Bioversity and CIAT, Kampala, Uganda, [4]International Affairs and Political Economy (DIA), Department of International Affairs and Political Economy, University of St. Gallen, St. Gallen, Switzerland, [5]Department of Environmental Biology, Sapienza University, Rome, Italy

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Introduction

The seed sector is one of the cornerstones in ensuring food security, nutrition, livelihoods, and environmental sustainability [Organization for Cooperation Economic Development (OECD), 2021]. Seeds are the most crucial production input, and access to productive seeds ensures resilience and sustainability, especially in traditional production systems of the low- and middle-income countries where agriculture makes the largest share of their economies and occupations.

Agricultural research is paramount to ensure that seeds match farmers' needs and increase productivity. For a long time, countries relied on their public sector for seed-science research and seed supply as an essential public good (Srinivasan, 2005). Sweeping regulations in seeds markets enabled the private sector to eventually obtain higher participation in agricultural research. Time and costs for developing new varieties laid the ground for intellectual property rights (IPR) acting as a strong incentive for private investment. This explains the unprecedented growth of the industry, enabling greater innovation (Srinivasan, 2003; UPOV, 2009).

The seed sector has been recently characterized by high levels of market concentration. Increasingly sophisticated technologies used in plant breeding require substantial investments in research, development, and seed production. Consequently, strategic mergers and acquisitions in the sector have enabled companies to leverage economies of scale and become vertically-integrated (Srinivasan, 2003; Deconinck, 2020). Today, the main seed producers are also producers of herbicides, fertilizers, and

other biotech products - such as Monsanto, Syngenta, and Corteva who control over 50% of the global seed market (Frison, 2016).

The fundamental differences between private and public research have shaped the evolution dynamics of the sector. Private companies tend to focus on innovations for big markets, both in terms of geographical coverage and crops of interest. Indeed, while the innovation rate has increased, it has been concentrated on a few crops. Innovation has adapted crops to specific production and consumption systems (Brooks and Loevinsohn, 2011; Gaffney et al., 2019). Still, it has often failed to respond to the needs of farmers and consumers in the traditional production systems of low-income countries (e.g., neglected and underutilized crops and farmers varieties)—that typically have fewer resources to make up for this innovation gap through public investments and research (Niggli et al., 2017; Macours, 2019).

What is at stake?

Planting crop diversity is key for small-scale farmers in low-income countries. A diversified production system helps farmers to cope with climate change uncertainties and, in general, with biotic and abiotic stresses by reducing the risk of total production losses (Jarvis et al., 2007, 2008; Jarvis and Hodgkin, 2008; Mulumba et al., 2012). A diversified production system may help to reduce the use of other production inputs such as pesticides and fertilizers, leveraging on complementarities and synergies of different crops which are usually more adapted to local environmental conditions (Finckh and Wolfe, 2006; Østergard et al., 2009; Mal et al., 2010). Seed systems supported by biodiversity are critical to improving the resilience of agriculture production systems through enhancing ecosystem services and ensuring human health (Hajjar et al., 2008).

Forgotten or underutilized crops (NUS) and local varieties play a key role in proving livelihoods to low-income farmers, lowering famine risks and providing more complete and balanced diets than typical monocultures (Kahane et al., 2013; Andersen et al., 2018; Hunter et al., 2019). However, in order for NUS and traditional varieties to contribute to improving wellbeing of small-scale farmers, their conservation and accessibility needs to be improved and secured.

Seed systems need to be healthy and dynamic, but often low access to innovation and limited availability of diversity leads to agricultural specialization in places where it is suboptimal or unwanted (Joshi et al., 2019). Lack of innovation results in poor quality of the planting materials and limited capacity to improve or simplify processing technologies to better respond to low-income farmers' nutrition or market needs.

Can community seed banks be part of the solution?

Community seed banks (CSBs) are becoming popular components of strategies aimed at increasing access and use of agrobiodiversity (Vernooy et al., 2014, 2017; Porcuna-Ferrer et al., 2020). CSBs are informal institutions managed by farmers that conserve and manage seeds, mostly local varieties but commercial ones can also be found. They aim to: increase seed diversity in order to better respond to farmers' needs; control the quality of materials provided; provide insurance in the form of increased seed supply options available to communities and improve social cohesion among members. Several functions make this model an important one in the seed systems and particularly relevant to the context of low-income areas.

The primary function of CSBs is related to the preservation of genetic resources (Shrestha et al., 2013). Local varieties are often the only source of planting material for small-scale farmers; they play an important role in continuing the adaptive process to environmental conditions in which seeds grow. CSBs promote on-farm conservation by collecting and conserving locally adapted seeds, which are normally not provided or underprovided by the formal seed system and the market. Preserving landraces, or farmers' varieties, is essential, as these varieties represent an important source of traits such as resistance to biotic and abiotic stress and nutritional qualities (Trutmann et al., 1996; Finckh and Wolfe, 2006; Duc et al., 2010; FAO, 2019) which are vital to ensure productivity, and resilience of smallholder production systems not to mention their importance in the continuous breeding of new varieties.

Another important function of CSBs regards the critical role of enhancing the availability and accessibility of these diverse genetic resources in sufficient quantities during planting season (Vernooy et al., 2014). Seeds and other planting materials are made available to community members either through seed loans (farmers borrow a small quantity of seeds to be returned at the end of the season) or seed sales. In this sense, CSBs are important financial instruments for farmers. They provide a *de facto* form of subsidy by facilitating seed procurement, which often represents the most important investment in subsistence agriculture.

Access to local seed providers such as CSBs guarantees a certain degree of independence and autonomy from the formal seed system. It can also provide farmers with economic opportunities to differentiate their offer. This is particularly true in developing countries, where formal seed system cover only a small fraction of the seed demand for major staple crops and neglect minor crops and local varieties (Shrestha et al., 2013). The Nakaseke CSB in Uganda has been able to increase the number of common beans varieties from 25 varieties in 2014 to 46 varieties in 2021, providing multiple biodiversity options for the most important food security crop in the country. Moreover,

the Nakaseke CSB has empowered its farmers to embrace good seed production and management practices through on-farm monitoring and training.

How CSB can help closing the innovation gap?

CSBs have great potential in scaling up innovation on local varieties and minor crops (Balázs and Aistara, 2018) which have a low economic value for main seed producers given the small market they represent. The local varieties they conserve represent an important source of traits for varietal improvement through breeding and further selection of new varieties. CSBs, supported by NGOs, governments and international organizations who provide technical support, can conduct experiments and field trials that test different varieties in their specific conditions and identify the most suitable ones to farmer needs (Vernooy et al., 2014). CSBs can also have a proactive role in participatory breeding activities to fill in the gap of the formal breeding system that cannot satisfy the demand and needs of farmers in most remote areas [Local Initiatives for Biodiversity, Research and Development (LI-BIRD), 2019]. By getting involved in developing and registering varieties, farmers gain ownership of new varieties resulting from breeding programs and can seize commercial opportunities.

Furthermore, CSBs facilitate the exchange of knowledge and reach out to community members and favor the gender inclusion. In fact, women usually play central roles in their management and youth have the opportunity to learn traditional knowledge and unleash innovation (Shrestha et al., 2013; Vernooy et al., 2014). As such, CSBs operate as a platform generating a ripple effect that is important not only for promoting agrobiodiversity in production systems but also for the entire community development.

Possible approaches for economic sustainability of community seedbanks

So far, we have discussed CSBs play multiple roles in seed systems, food security, and innovation. Despite all the beneficial roles played by community seedbanks, their economic sustainability remains a challenge (Richardson, 2010; Sthapit, 2012; Frison, 2018; Isbell et al., 2021). Their economic sustainability is often overlooked in program design stages but is key to deliver sustainable impact (Vernooy et al., 2014). Many CSBs are part of informal seed market systems while only a few are authorized to operate in formal systems (Vernooy et al., 2015). This means that CSBs continue facing limitations for registering and commercializing their varieties despite being able to exchange seeds with local farmers. Community seedbanks mainly deal with farmer varieties (local varieties), but in many countries, these are not registered on the national catalog of varieties as they do not go through formal breeding. This limits their being traded legally over a wide area and calls for development of procedures to have them registered on the national catalogs of varieties.

For CSBs obtaining legal status would open their field of action: allowing them to develop strategic partnerships with public and private entities to participate and contribute to scientific research activities (e.g., selection and improvement of plant genetic material) with the support of public funds; or engage with private sector to actively participate in value chains, enhancing greater ownership of genetic resources and profit sharing from resulting outcomes. For instance, breeders developing new varieties coming from material from community seed banks should enter into formal partnerships with these communities so that they both benefit from their intellectual properties gains and commercialization. In Nepal, for example, some CSBs, operating under local cooperatives and civil society organizations, have already started to collaborate with formal sector agencies in registering and maintaining varieties (Maharjan and Mahjarjan, 2017; Shrestha et al., 2020).

From our experience, there is an unmet demand for local varieties that CSBs can fill if allowed to interact with markets. In Nepal, the surging demand for local crops has led to the registration of six local varieties that are important for food security of the most vulnerable mountainous communities (Gauchan et al., 2018). The Community Seed Bank Association of Nepal (CSBAN) reports that only 1/3 of their seeds are locally used to meet their farmers' demand, while the rest is marketed outside of their local reach (Shrestha, 2020). This highlights the importance and need for more diverse and better-regulated seed systems.

Ultimately, CSBs will benefit from better market integration. To enhance the competitiveness of local crop diversity, market strategies should look at integration in the food system (Bovarnick and Gupta, 2003; Gruère et al., 2006, 2007). Forms of horizontal integration, such as cooperatives, farmers' groups, consortiums, generate greater external empowerment and are better positioned to access funding, which can be invested in technologies and growth. For instance, these investments could be on acquisitions of further steps or processes along the value chain, such as processing or labeling. By getting involved in value chains, CSBs and other associative structures can contribute to recapture additional value and increase revenues. Similarly, adopting certifications and developing short-value chains and local food systems at CSB levels can help increase the demand for local products and allow more direct communication and engagement with final consumers (NU. CEPAL FAO IICA., 2015; Lamers et al., 2016). Additional benefits can come from valuing other characteristics, such as local production, respect for social conditions of workers, nutritional value and agrobiodiversity conservation. CSBs can take advantage of these benefits and additional elements by developing local markets or food hubs (Manikas et al., 2019). Recently, some CSBs in Nepal

initiated marketing of local diverse nutritional food products that indirectly promote local seed varieties and support local food value chains.

Economic models can also be based on micro-financing systems. In this model, CSBs could function as small credit banks that provide loans without collateral to guarantee access to fair financing to its members for income-producing activities both on- and off-farm (Shrestha et al., 2012). In earlier stages, community members finance initial funds, which can be later increased by external sources. Credit concedes priority to the poorest farmers, and a fair interest rate is asked in return to cover operational expenses. In places where this model has been implemented like in many CSBs in Nepal, most poor farmers have taken a loan from CSBs without significant loan repayment issues (Choudhary et al., 2021).

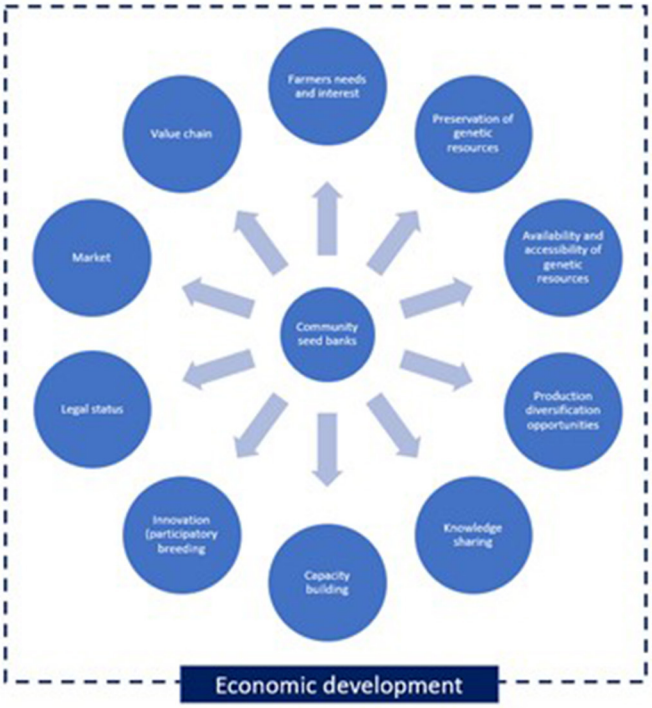
CSBs multiple functions on conservation and accessibility of different planting material together with market involvement, hold the capacity to trigger a virtuous circle where economic activities and economic development go hand in hand with improving agrobiodiversity. The diagram (Figure 1) summarizes functions and features for a CSB model where economic development can support in its long-term functionality.

Conclusions

Access to diverse planting material enables farmers to cope with uncertainties and choose the crop system that best fits their needs, both of the market they want to address and the local production conditions they face. In low and middle-income countries, agrobiodiversity in the production system is even more important as it often responds to the self-sufficiency of the farm and the community.

This community seedbank represents a unique opportunity to improve agrobiodiversity in the production system. This model holds the potential to enhance the conservation of local varieties, better suited to local production specificities. CSBs roles discussed in this paper show that CSBs can effectively integrate the formal and informal seed systems to improve food security and can be a platform to trigger innovation adoption through a bottom-up approach and stimulate community development.

Investing in their economic sustainability, which often remains overlooked, is critical. Main challenges facing CSBs are related to lack of their recognition as legal entities, investments to valorize local crops on markets and create higher CSB participation in food systems. Nevertheless, there are several opportunities for economic sustainability. These could be



Community seed banks are collective-action institutions administered by farmer members, whose central function is to manage and maintain planting material of both local and improved varieties, and to guarantee access and availability of diverse planting material at the right time and in sufficient quantities to satisfy farmers' needs and interests.

In order for the CSBs to effectively perform these functions, it is necessary that they are economically sustainable. This requires that their legal status is recognized, members are knowledgeable and engage in agriculture-related topics (e.g. seed conservation, seed multiplication, breeding) as well as in agribusiness (e.g. processing, marketing, micro-financing) so they can develop economically by increasing their participation in market and value chains.

CSBs hold the capacity to trigger a virtuous circle where economic activities and better livelihoods go hand in hand with improving agrobiodiversity.

FIGURE 1
Conceptual framework illustrating the functions and features of long-term functional community seed banks.

through market channels and credit and saving mechanisms that offer the potential to enhance the social functions of CSBs.

Author contributions

ED, DG, RN, PD, SM, DJ, and LL contributed to the conceptualization of the work. ED and PD wrote the first draft of the paper. All authors reviewed the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Andersen, R., Otieno, G., Kasasa, P., and Mushita, A. (2018). Community Seed Banks: Sharing Experiences from North to South. *Report from a side event during the Seventh Session of The Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture. Kigali, Rwanda*. Available from: https://www.bioversityinternational.org/fileadmin/user_upload/Community_Andersen_2018.pdf

Balázs, B., and Aistara, G. (2018). The emergence, dynamics and agency of social innovation in seed exchange networks. *Int. J. Sociol. Agricult. Food* 24. doi: 10.48416/ijsaf.v24i3.9

Bovarnick, A., and Gupta, A. (2003). Local business for global biodiversity conservation. *Improving the Design of Small Business Development Strategies in Biodiversity Projects*. New York, NY: UNDP/GEF.

Brooks, S., and Loevinsohn, M. (2011). "Shaping agricultural innovation systems responsive to food insecurity and climate change," in *Natural Resources Forum, vol. 35* (Oxford, UK: Blackwell Publishing Ltd), 185–200

Choudhary, D., Banskota, K., Khanal, N., and Gyawali, P. (2021). The role of access to finance for smallholders' seed business growth in Nepal. *Dev. Pract.* 31, 139–149. doi: 10.1080/09614524.2020.1828828

Deconinck, K. (2020). Concentration in Seed and Biotech Markets: Extent, Causes, and Impacts. *Ann. Rev. Resour. Econ.* 12, 129–47. doi: 10.1146/annurev-resource-102319-100751

Duc, G., Bao, S., Baum, M., Redden, B., Sadiki, M., Suso, M. J., et al. (2010). Diversity maintenance and use of *Vicia faba* L. genetic resources. *Field Crop Res.* 115, 270–278. doi: 10.1016/j.fcr.2008.10.003

FAO (2019). *Voluntary Guidelines for the Conservation and Sustainable Use of Farmers' Varieties/Landraces*. Rome: FAO.

Finckh, M. R., and Wolfe, M. S. (2006). "Diversification strategies," in *The Epidemiology of Plant Diseases,* eds. Cooke B. M., Jones D. G.,and Kay B. (Dordrecht, Netherlands: Springer), 269–308.

Frison, C. (2018). *Redesigning the Global Seed* Commons: *Law and Policy for Agrobiodiversity and Food Security*. England, https://www.google.com/search?q=UK&stick=H4sIAAAAAAAAAONgVuLQz9U3MC8uTl7EyhTqDQBuxFlpEQAAAA&sa=X&ved=2ahUKEwjQho_v2ND4AhVZmIQIHdAoCaIQmxMoBHoECE8QBg UK: Routledge.

Frison, E. A. (2016). *From Uniformity to* Diversity: *A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems*. Brussels, Belgium: International Panel of Experts on Sustainable Food systems.

Gaffney, J., Challender, M., Califf, K., and Harden, K. (2019). Building bridges between agribusiness innovation and smallholder farmers: a review. *Global Food Securi.* 20, 60–65. doi: 10.1016/j.gfs.2018.12.008

Gauchan, D., Joshi, B. K., and Bhandari, B. (2018). "Farmers' rights and access and benefit sharing mechanisms in community seed banks in Nepal," in *Community Seed Banks in Nepal: Proceedings of the 2nd National Workshop*, eds Joshi B. K., Shrestha P., Gauchan D., Vernooy R. (Kathmandu. NAGRC, LI-BIRD and Bioversity International), 117–132.

Gruère, G. P., Giuliani, A., and Smale, M. (2006). Marketing underutilized plant species for the benefit of the poor: a conceptual framework. *IFPRI Environmental and Protection Technology (EPT) Discussion Paper No.* 154.

Gruère, G. P., Nagarajan, L., and Oliver King, E. D. I. (2007). *Collective Action and Marketing of Underutilized Plant Species: The Case of Minor Millets in Kolli Hills, Tamil Nadu, India. WP N. 69*. The CGIAR Systemwide Program on Collective Action and Property Rights (CAPRi).

Hajjar, R., Jarvis, D. I., and Gemmill-Herren, B. (2008). The utility of crop genetic diversity in maintaining ecosystem services. A review. *Agricult. Ecosyst. Environ*. 123, 261–270. doi: 10.1016/j.agee.2007.08.003

Hunter, D., Borelli, T., Beltrame, D. M. O., Oliveira, C. N. S., Coradin, L., Wasike, V. W., et al. (2019). The potential of neglected and underutilized species for improving diets and nutrition. *Planta*. 250, 709–29. doi: 10.1007/s00425-019-03169-4

Isbell, C., Tobin, D., and Reynolds, T. (2021). Motivations for maintaining crop diversity: evidence from Vermont's seed systems. *Ecol. Econ*. 189, 107–138. doi: 10.1016/j.ecolecon.2021.107138

Jarvis, D. I., Brown, A. D. H., Imbruce, V., Ochoa, J., Sadiki, M., Karamura, E., et al. (2007). "Managing crop disease in traditional agroecosystems: the benefits and hazards of genetic diversity," in *Managing Biodiversity in Agricultural Ecosystems*, eds Jarvis D. I., Padoch C., and Cooper D., (New York, USA: Columbia University Press), 292–319

Jarvis, D. I., Brown, A. H. D., Cuong, P. H., Collado-Panduro, L., Latournerie-Moreno, L., Gyawali, S., et al. (2008). A global perspective on the richness and evenness of traditional crop-variety diversity maintained by farming communities. *Proc. Natl. Acad. Sci.* 105, 5326–31. doi: 10.1073/pnas.0800607105

Jarvis, D. I., and Hodgkin, T. (2008). The maintenance of crop genetic diversity on farm: supporting the convention on biological diversity's programme of work on agricultural biodiversity. *Biovers. Int.* 9, 23–38. doi: 10.1080/14888386.2008.9712876

Joshi, K. D., Conroy, C., and Witcombe, J. R. (2019). Agriculture, seed, and innovation in Nepal: industry and policy issues for the future [version 1; not peer reviewed]. *Gates Open Res.* 3, 23.

Kahane, R., Hodking, T., Jaenicke, H., Hoogendoorn, C., Hermann, M., Keatinge, J. D. H., et al. (2013). Agrobiodiversity for food security, health and income. *Agron. Sustain. Dev*. 33, 671–93. doi: 10.1007/s13593-013-0147-8

Lamers, H. A. H., Kruijssen, F., Sthapit, B., and Rao, R. V. (2016). "How can Markets Contribute to the Conservation of Agricultural Biodiversity on Farms? From Theory into Practice," in *Tropical Fruit Tree Diversity: Good practices for in situ and on-farm conservation*, eds Bhuwon Sthapit, Hugo A.H. Lamers, V. Ramanatha Rao, Arwen Bailey. England, UK: Earthscan from Routledge. Available from: https://www.bioversityinternational.org/fileadmin/user_upload/online_library/publications/pdfs/Tropical_Fruit_Tree_Diversity/22_Markets_Conservation_Biodiversity.pdf

Local Initiatives for Biodiversity, Research and Development (LI-BIRD). (2019). *Views, Experiences and Best Practices as an Example of Possible Options for the National Implementation of Article 9 of the International Treaty*. Rome, Italy: FAO/ITPGR. Available from: http://www.fao.org/3/ca8144en/ca8144en.pdf (accessed July, 2021).

Macours, K. (2019). Farmers' demand and the traits and diffusion of agricultural innovations in developing countries. *Annual Review of Resource Economics*. 11, 483–499. doi: 10.1146/annurev-resource-100518-094045

Maharjan, S. K., and Mahjarjan, K. L. (2017). Community Seed Banks in Nepal: Prospects and Challenges from the Perspective of Climate Change Adaptation. *International Journal of Ecology and Environmental Sciences*. 43, 221–227.

Mal, B., Padulosi, S., and Ravi, S. B. (2010). *Minor Millets in South* Asia: Learnings from IFAD-NUS Project in India and Nepal. Bioversity International and the M.S. Swaminathan Research Foundation.

Manikas, I., Malindretos, G., and Moschuris, S. A. (2019). Community-Based Agro-Food Hub Model for Sustainable Farming. *Sustainability*. 11, 1017. doi: 10.3390/su11041017

Mulumba, J. W., Nankya, R., Adokorach, J., Kiwuka, C., Fadda, C., De Santis, P., et al. (2012). A risk-minimizing argument for traditional crop varietal diversity use to reduce pest and disease damage in agricultural ecosystems of Uganda. *Agriculture, Ecosystems and Environment*. 157, 70–86. doi: 10.1016/j.agee.2012.02.012

Niggli, U., Andres, C., Willer, H., and Baker, B. P. (2017). Building a global platform for organic farming research, innovation and technology transfer. *Organic Agriculture*. 7, 209–224. doi: 10.1007/s13165-017-0191-9

NU. CEPAL FAO IICA. (2015). *Short food supply chain as an alternative for promoting family agriculture*. CEPAL. Available from: https://www.cepal.org/en/publications/37745-short-food-supply-chain-alternative-promoting-family-agriculture.

Organization for Cooperation and Economic Development (OECD) (2021). The contribution of the seed sector to the triple challenge. In: Making Better Policies for Food Systems. OECD, pp 123–171.

Østergard, H., Finckh, M. R., Fontaine, L., Goldringer, I., Hoad, S. P., Kristensen, K., et al. (2009). Time for a shift in crop production: embracing complexity through diversity at all levels. *J. Sci. Food Agric*. 89, 1439–1445. doi: 10.1002/jsfa.3615

Porcuna-Ferrer, A., Fiala, V., Freyer, B., van Etten, J., Vernooy, R., Probst, L., et al. (2020). Do community seed banks contribute to the social-ecological resilience of communities? A case-study from Western Guatemala. *International Journal of Agricultural Sustainability* 18, 232–249. doi: 10.1080/14735903.2020.1747199

Richardson, R. B. (2010). Ecosystem services and food security: Economic perspectives on environmental sustainability. *Sustainability*, 2, 3520–3548. doi: 10.3390/su2113520

Shrestha, P. (2020). *Community Seed Banks for Saving and Producing Seeds of Traditional Crop Varieties (Nepali version). Briefing Paper*. LI-BIRD. Available from: http://libird.org/app/publication/view.aspx?record_id=381

Shrestha, P., Clancy, E., and Vernooy, R. A. (2020). Level up: Community Seed Banks in Nepal Join Forces. Rome (Italy): *Bioversity International; Pokhara (Nepal): LI-BIRD*. Available from: https://hdl.handle.net/10568/108049.

Shrestha, P., Sthapit, S., Paudel, I., Subedi, A., and Sthapit, B. (2012). Guide to Establishing a Community Biodiversity Management Fund for Enhancing Agricultural Biodiversity Conservation and Rural Livelihoods. Local Initiatives for Biodiversity, Research and Development (LI-BIRD). Available from: https://www.academia.edu/21688760/Guide_to_Establishing_a_Community_Biodiversity_Management_Fund_for_Enhancing_Agricultural_Biodiversity_Conservation_and_Rural_Livelihoods

Shrestha, P., Vernooy, R., and Chaudhary, P. (2013). *Community seed banks in Nepal past, present, future: Proceedings of a National Workshop, 14-15 June 2012, Pokhara, Nepal*. Pokhara (Nepal): Local Initiatives for Biodiversity, Research and Development (2013).

Srinivasan, C. S. (2003). Concentration in ownership of plant variety rights: some implications for developing countries. *Food Policy* 28, 519–46. doi: 10.1016/j.foodpol.2003.10.003

Srinivasan, C. S. (2005). The international trends in plant variety protection. *Elect. J. Agric. Dev. Econ.* 2, 2. 38. doi: 10.22004/ag.econ.110134

Sthapit, B. (2012). "Emerging theory and practice: community seed banks, seed system resilience and food security," in *Proceedings of the National Workshop Community Seed Banks in Nepal: Past, Present, Future, Pokhara, Nepal, 14–15 June 2012*, eds Shrestha P., Vernooy R., Chaudhary P., editors. (Pokhara, Nepal: Local Initiatives for Biodiversity, Research and Development (LIBRD); Rome, Italy: Bioversity International), 16–40.

Trutmann, P., Voss, J., and Fairhead, J. (1996). Indigenous knowledge and farmer perception of common bean disease in the central African highlands. *Agric. Hum. Values* 13, 64–70. doi: 10.1007/BF01530524

UPOV (2009). *International Union for the Protection of New Varieties of Plants (UPOV) UPOV Report On The Impact Of Plant Variety Protection*. Available from: https://www.upov.int/export/sites/upov/about/en/pdf/353_upov_report.pdf (accessed October, 2021).

Vernooy, R., Shrestha, P., and Sthapit, B. (2015). *Community Seed Banks: Origins, Evolution, and Prospects. Issues in Agricultural Biodiversity*. London, New York: Routledge, Taylor and Francis Group.

Vernooy, R., Sthapit, B., Galluzzi, G., and Shrestha, P. (2014). The multiple functions and services of community seedbanks. *Resources* 3, 636–56. doi: 10.3390/resources3040636

Vernooy, R., Sthapit, B., Otieno, G., Shrestha, P., and Gupta, A. (2017). The roles of community seed banks in climate change adaption. *Dev. Pract.* 27, 316–327. doi: 10.1080/09614524.2017.1294653